SOIL NUTRIENT EFFECTS ON GOLDENROD GALLS FORMED BY *EUROSTA SOLIDAGINIS* (DIPTERA: TEPHRITIDAE)[1]

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ABSTRACT: The soil nutrient effects on single and multiple (double, triple) goldenrod galls made by *Eurosta solidaginis* were studied at four sites in upstate New York. Negative correlations between the percentage of multiple galls sampled and the amounts of nitrogen and magnesium in the soil were noted. No significant correlations were found between galls and the amounts of potassium, phosphorus, or calcium. Of the galls collected, 79.6% were on the variety *Solidago canadensis scabra*, and 20.4% on the variety *S. c. canadensis*.

The biology and ecology of goldenrod galls formed by *Eurosta solidaginis* Fitch have been investigated by several authors (Ping 1915; Hughes 1934; Uhler 1951, 1961; Miller 1959). Milne (1940) studied the biotic potential of *E. solidaginis*, and Cane and Kurczewski (1976) reported on some mortality factors, including predation and parasitism, in single and multiple galls. More recently, Hartnett and Abrahamson (1979) and Stinner and Abrahamson (1979) have treated the resource allocation patterns and energy budgets, respectively, associated with *Solidago canadensis* (L.) L. gall insects. No study has addressed the soil fertility factors that affect the formation of multiple versus single galls. This paper deals with the effects of soil nutrients on multiple ball gall formation.

METHODS AND MATERIALS

Solidago canadensis galls were collected from four study plots in Onondaga County, NY in September and October 1983, using a square meter grid random sampling method. The specimens were compared with mounts in the SUNY-CESF Herbarium, separated into the varieties *canadensis* (L.) L. and *scabra* (Muhl.) T. & G., and further divided into single and multiple (double, triple) types.

Four sites of varied topographies and soil qualities were selected for study. Each site is naturally delimited from surrounding habitats and covers an area of approximately 2000 sq m. The sites are as follows:

Site A. Once a city garbage dump, this site lies on a gently sloping flood plain on the southeastern side of Syracuse. The soil is yellow-brown with a sticky, clay-like texture. Within the site *Solidago canadensis* is the most abundant species, with frequent *Rumex* spp., *Daucus carota* L., *Hieracium*

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spp., and scattered grasses, sedges, and other wastebed species.

Site B. Also in the southeastern side of Syracuse, this site is in a shallow basin. The soil is dark and loose, with a large amount of gravel. *Solidago canadensis, Aster simplex* L., *A. novae-angliae* L., and various Compositae dominate the herbaceous growth. *Rhamnus cathartica* L., *Cornus* sp., and *Rubus* sp. are scattered throughout the site.

Site C. This site is in a depression at the base of a drumlin in DeWitt, NY. Parts of the site have standing water and the soil is dark and loamy. There is a large, well developed stand of *Rhamnus cathartica* on one side, several large *Populus tremuloides* Michx., and many *Rosa multiflora* Thunb. Grasses are abundant and there is a small stand of *Phragmites communis* Trin. *Solidago canadensis* is the dominant plant.

Site D. This site is along railroad tracks adjacent to a wooded cemetery just south of the SUNY-CESF campus, Syracuse. The soil is gray and gravelly with a noticeable amount of petroleum mixed in. *Solidago canadensis* is abundant but patchy. Other common herbs include *Asclepias syriaca* L., *Verbascum thapsus* L., *Dipsacus sylvestris* L., and scattered grasses. The site contains *Acer negundo* L., *Acer saccharum* Marsh, *Acer saccharinum* L., *Ulmus americana* L., *Rhus typhina* L., *Juglans nigra* L., *Quercus alba* L., *Catalpa speciosa* Warder, and *Rhamnus cathartica.*

Three rooting-depth core samples were collected from each site and analyzed for phosphorus and nitrogen as per Wilde *et al.* (1979), and for potassium, magnesium, and calcium by atomic absorption (Analytical Methods for Atomic Absorption Spectrophotometry 1976).

The mean element values were plotted against the percentage of multiple galls for each site. The best fitting line was drawn using the least squares method, and statistical significance was determined through the application of F distribution and R square testing (Sokal and Rohlf 1969). Null hypothesis rejection was set at the 95% level of confidence.

RESULTS

S. canadensis specimens with galls (N = 2036) were determined to be 79.6% var. *scabra* and 20.4% var. *canadensis* (Table 1). Individual site percentages were as follows: Site A - *scabra,* 83.6%, *canadensis,* 16.4%; Site B - *scabra,* 81.6%, *canadensis,* 18.4%; Site C - *scabra,* 80.0%, *canadensis,* 20.0%; Site D - *scabra,* 73.9%, *canadensis,* 26.1%.

The mean amounts of soil nutrients (N, P, Ca, Mg, K) found at the four study sites are shown in Table 2. A negative correlation exists between the percentage of multiple galls collected and the amount of nitrogen in the soil at three of the four sites(Fig. 1). Petroleum at Site D interfered with soil nitrogen testing, nullifying the test. Regression by least squares of %

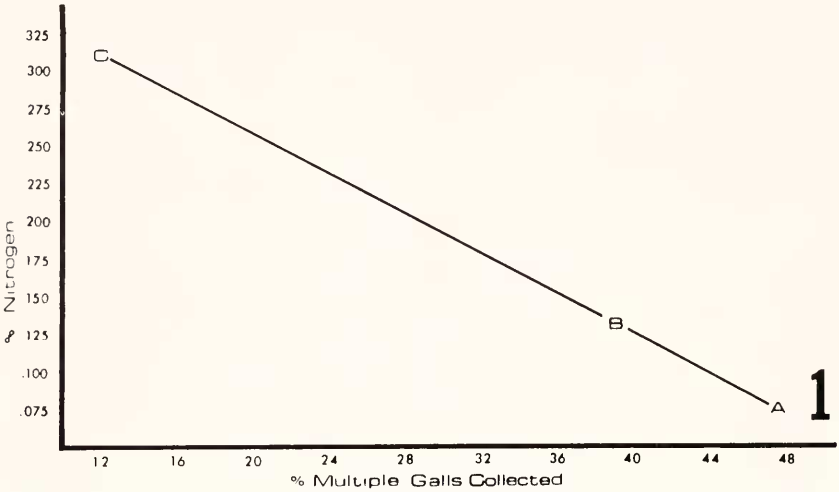

Fig. 1. Percent nitrogen plotted against percent multiple galls collected at three study sites (A-C) in Onondaga County, NY.

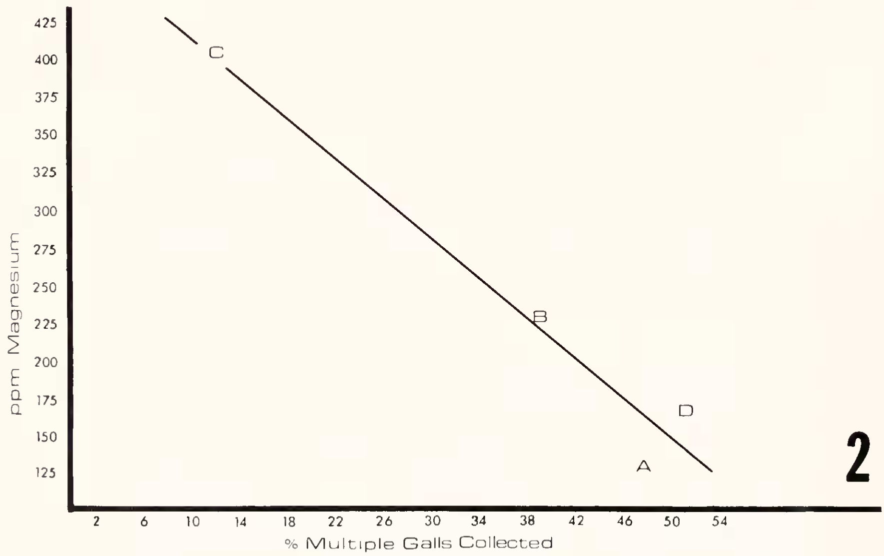

Fig. 2. Ppm magnesium plotted against percent multiple galls collected at four study sites (A-D) in Onondoga County, NY.

multiple galls against % nitrogen gives the equation Y = .00659 x + .388, with $R^2 = .9999996$. A negative correlation exists between the percentage of multiple galls collected and the amount of magnesium in the soil (Fig. 2). Regression by least squares of % multiple galls against ppm magnesium gives the equation Y = 6.606 x +480.635, with $R^2 = .978$. No significant correlations exist between the percentages of multiple or single galls and the amounts of potassium, phosphorous, or calcium.

DISCUSSION

Essentially nothing is known about the influence of soil magnesium on the development of phytophagous insects. However, magnesium is a constituent of chlorophyll and a cofactor of nearly all enzymes which act on phosphorylated substrates, and thus is important in energy metabolism. Epstein (1972) notes that magnesium deficiency affects every aspect of the metabolism of the plant. Clearly, an element with such widespread effects on plant vigor would in turn affect the survival rates of gall forming insects.

Table 1. Number of single (S) and multiple (M) galls, with percentages, on *Solidago canadensis* vars. *scabra* and *canadensis* at four sites in Onondaga Co., NY.

		scabra		*canadensis*		Total	
Site		N	%	N	%	N	%
Site A	S	247	51.7	53	56.4	300	52.4
	M	231	48.3	41	43.6	272	47.6
Site B	S	217	56.9	68	79.1	285	61.0
	M	164	43.1	18	20.9	182	39.0
Site C	S	287	87.5	74	90.2	361	88.0
	M	41	12.5	8	9.8	49	12.0
Site D	S	213	49.1	70	45.8	283	48.2
	M	221	50.9	83	54.2	304	51.8
Subtotals	S	964	59.5	265	63.9	1229	60.4
	M	657	40.5	150	36.1	807	39.6
Totals		1621	79.6	415	20.4	2036	100.0

Table 2. Amounts of soil nutrients in pct N, or ppm P, Ca, Mg, K at four study sites in Onondaga Co., NY expressed as mean values ± S.D.

	Site			
	Site A	Site B	Site C	Site D
N	.074 ± .065	.131 ± .025	.309 ± .051	—
P	19.80 ± 6.70	15.70 ± .989	15.67 ± 4.04	14.50 ± .707
Ca	5962.00 ± 429.06	4527.93 ± 553.03	3562.02 ± 406.90	3889.16 ± 609.68
Mg	132.00 ± 27.50	228.36 ± 38.46	403.26 ± 43.21	165.44 ± 24.42
K	97.40 ± 43.48	103.50 ± 35.36	129.12 ± 29.02	149.56 ± 32.31

Increased soil nitrogen appears to provide some resistance to multiple gall formation in *S. canadensis*. High soil nitrogen can limit proteolysis in the plant, which decreases the amounts of soluble amino acids, thus reducing the levels of sap nitrogen (Tingey and Singh 1980). Depleted sap nitrogen levels may limit the number of larvae each stem can support.

The literature contains numerous conflicting results of studies on the influence of nitrogen on reproduction of phytophagous arthropods. Harries (1966) found that nitrogen deficient plants were less favorable for reproduction of two-spotted spider mites, *Tetranychus urticae* Koch. In contrast, Rodriguez (1951) found lower populations of *T. urticae* associated with high nitrogen levels in tomato plants. Painter (1951) compiled a list of studies that show that high soil fertility, especially high nitrogen levels, results in decreased plant injury by some insect species and increased injury by others.

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